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THE INTERPRETIVE STRUCTURAL MODELING SYSTEM.(U)
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THE INTERPRETIVE STRUCTURAL MODELING SYSTEM

DEFENSE COMMUNICATIONS AGENCY

COMMAND AND CONTROL TECHNICAL CENTER

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(6) THE INTERPRETIVE STRUCTURAL MODELING SYSTEM.

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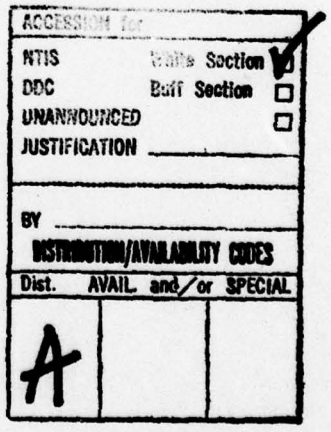
The computer program described in this manual, as well as the manual itself, was initially developed by Mr. Grady Clendenning at Battelle Memorial Institute, Columbus, Ohio. This version of the program was implemented at the University of Arizona under the guidance of Dr. Larry Schooley, while the present version is operational at the Command and Control Technical Center, Washington, D.C.



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ABSTRACT

The interpretive structural modeling process transforms unclear, poorly articulated mental models of systems into visible, well-defined models useful for many purposes. This is done through the systematic iterative application of graph theory to produce a directed graph of a particular contextual relationship among an element set. This manual briefly describes interpretive structural modeling, then documents an interactive computer program developed to assist in the modeling process. The program is written in FORTRAN and operates on a Honeywell H6000 under GCOS TSS.

1.0 INTRODUCTION

1.1 General

Interpretive Structural Modeling System (ISMS) is a computer implemented aid for conducting an Interpretive Structural Modeling (ISM) session, which helps people think and communicate more effectively about complex issues. This technique has been implemented in such a way that people are responsible for making all subjective judgments, while a computer is used in an unobtrusive manner for bookkeeping and for displaying the results and implications of the judgmental decisions made.

The fundamental concepts of ISM involve an "element set" and a "relationship." The element set is a collection of issue statements identified within the context of a problem situation. These statements must be derived from the problem situation by the planners themselves and may reflect such issues as objectives, goals, factors, activities, obstacles, etc. The relationship is a single verb clause that permits planners to make a common comparison of all pair-wise combinations of issue statements in the element set, for example: "is related to" or "is required for." Thus, in conducting an exercise, the participants are subjected to a series of questions in the form "is element A related to element B?" or similar questions more appropriate to the context of the problem being addressed. In a group session, the participants are presented with this element relationship question and are given the opportunity to discuss it until all participants have a mutual understanding of its meaning. This discussion also permits different viewpoints to be presented before the relationship is affirmed or denied, either by consensus or by a vote. The result of the consensus or vote for each question is recorded and the appropriate bookkeeping is performed by the computer until the session is finished.

At the conclusion of a session, the participants are presented with a directed graph (digraph) or network model whose nodes represent the original issue statements and whose lines define the presence of relationships established by the opinions of the users. This digraph is then used to produce the model of the specific problem situation. This model is derived from the digraph by introducing appropriate interpretive symbols and/or notation to form a structural model reflecting the established relationships among the original set of complex issue statements, hence the term interpretive structural model.

1.2 Benefits

The potential benefits to be realized from ISMS include the following; The ISMS:

a. Guides and records the results of group deliberations on complex issues in an efficient and systematic manner

b. Produces a structured model or graphical representation of the original problem situation that can be communicated more effectively to others

c. Enhances the quality of interdisciplinary and interpersonal communication within the context of the problem situation by focusing the attention of the participants on one specific question at a time, namely the relationship question. In this manner, it tends to reduce heated arguments over potentially volatile or sensitive issues

d. Promotes the use of information rather than the generation of data thereby placing no technical demands upon potential participants

e. Encourages issue analysis by allowing participants to explore the adequacy of a proposed list of issue statements for illuminating a specified problem situation

f. Serves as a learning tool by forcing participants to develop a deeper understanding of the meaning and significance of a specified list of issue statements

g. Permits action or policy analysis by assisting participants in identifying particular areas for policy action which offer advantages or leverage in pursuing specified objectives.

1.3 Advantages

The primary advantages of the ISM methodology are the following:

a. No knowledge of the underlying process is required of the participant; he simply must possess enough knowledge of the problem situation to be able to respond "yes" or "no" to the sequence of relational questions presented by the computer.

b. The process is systematic; the computer is programmed to consider all possible pair-wise

relations of issue statements, either through responses of the participants to direct relational questions or by transitive inference based upon previous responses.

c. ISM capitalizes upon the efficiency gained from transitive inference; if element a is related to element b and element b is related to element c, then the computer is programmed to infer that element a is related to element c, and that relational question need not be asked. Depending upon the context of the exercise, the use of transitive inference may reduce the required number of relational questions by 50 to 80 percent.

1.4 Applications

Applications where ISM has been applied successfully include the following:

a. National policy for achieving energy self-sufficiency

b. Goals and objectives for the Ohio Environmental Planning Agency

c. Obstacles to investment in the central city

d. Priority of ADP system specifications

e. National values

f. Factors influencing technology assessment

g. Socioeconomic impact of industrial plant location

h. Objectives of the Board of Engineering, Manpower and Education Policy

i. Objectives for national urban policy

j. Transportation research opportunities

k. Goals for the City of Dallas, Texas

l. Objectives for fossil fuel research and development program

m. Societal trends affecting the future of American governance

n. Elements of a systems development and planning process

o. Objectives for a local criminal justice coordinating council

p. Educational objectives for a small college or university.

1.5 Basis and Foundation

The term Interpretive Structural Modeling refers to the systematic application of some elementary notions of graph theory in such a way that theoretical, conceptual, and computational leverage is exploited to construct a directed graph, or network representation, of the complex pattern of a contextual relationship among a set of issue statements or elements.

The mathematical foundations of the methodology can be found in various reference works, e.g., Harary(1), et al. The philosophical basis for the development of the ISM approach has been presented in Warfield (2), and the conceptual and analytical details of the ISM process are also outlined in Warfield.

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1. Harary, F. Norman, R. Z., and Cartwright, D., Structural Models: An Introduction to the Theory of Directed Graphs, John Wiley and Sons, 1965.

2. Warfield, J. N., Societal Systems, John Wiley and Sons, Inc., 1967.

2.0 CONCEPTS AND OPERATION OF ISM

This section presents an overview of the principal operations, fundamental concepts, basic user steps, and output products that constitute the ISM system.

2.1 The ISM Process

The process of ISM is based upon the one-to-one correspondence between a binary matrix and a graphical representation of a directed network. The basic units of the process are an "element set" of issue statements and a "transitive relation" (relational clause). The element set is identified within some issue context (problem situation), and the relation is selected as a possible statement of relationship among the elements in a manner that is also contextually significant. These elements of issue statements correspond to the nodes on a network model, and the presence of the relationship between any two issue statements is denoted by a directed line or link connecting those two statements (nodes). In the equivalent binary matrix representation, the elements form the contents of the index set for the rows and columns of the matrix, and the presence of the relationship directed from element i to element j is indicated by placing a 1 in the corresponding intersection of row i and column j. Then in conducting an exercise, a group is subjected to a series of queries of the form "is element a related to element b?," or a similar statement more appropriate to the context. The consensus view of the group as to whether the answer to the query is "yes" or "no" determines whether a 1 or a 0, respectively, is entered in the appropriate location of the matrix.

2.2 Principal Operations

Figure 2-1 is a representation of the principal operations involved in applying the technique in a man/machine interactive mode. People are assumed to make observations in the real world and to draw upon their own knowledge and attitudes to identify pertinent concepts and relationships. The embedding operation is performed jointly by man and machine. The computer is supplied with an appropriate list of issue statements and the definition of a pertinent relationship. A systematic sequence of relational questions is then generated, and a binary matrix representation of the system is assembled from the responses provided by a participant or group of participants. When the matrix model is completed, computer operations are performed in order to partition the issue statements into natural hierarchical levels (partitioning) and to establish a minimal set of linkages which capture the entire pattern of the relationships (extracting). The multilevel directed graph (digraph) which results can be inspected and interpretive

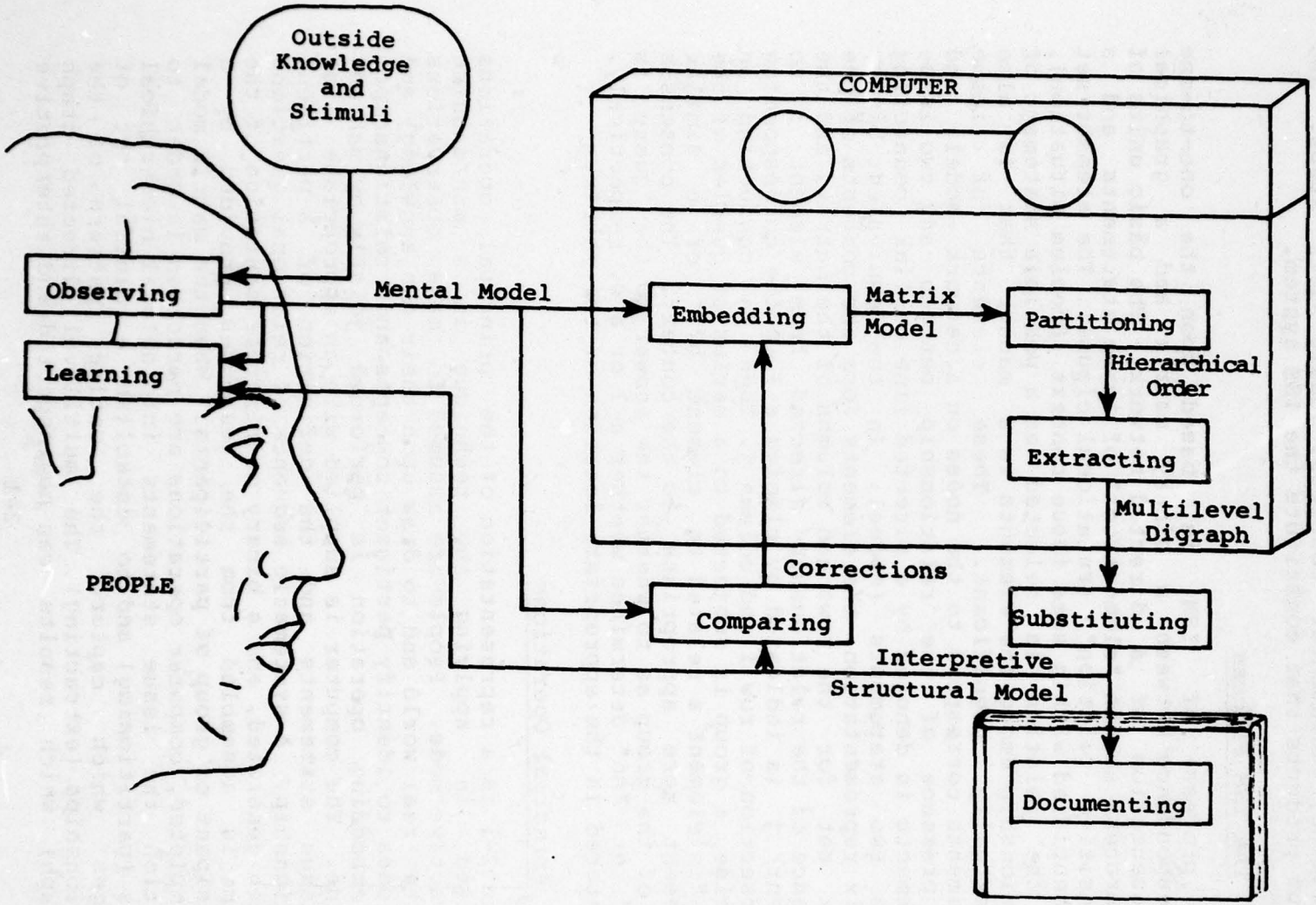

Figure 2-1. Functional Representation of Interpretive Structural Modeling, Showing Potential for Man/Machine Symbiosis.

symbols introduced according to the context (substituting) to produce an interpretive structural model. If the creators of the model are satisfied, it can be documented for purposes of communicating it to others. If there are deficiencies or errors in the model (comparing), a correction process can be executed, again in partnership with the computer. Note that the entire process has learning implications for the participants as well as providing documentation of the results of the exercise.

2.3 The Fundamental Concepts of ISM

The fundamental concepts of ISM involve the following:

a. Issue context

b. Element set

c. Relational clause

d. Directed graph or digraph

e. Interpretive Structural Model

The issue context represents a combination of complex issues, either stated or implied in this same context that properly reflects the current state of conditions or circumstances under which a problem is commonly perceived to exist. It is from this issue context that ISM users must derive the pertinent element set.

The element set is the collection of specific issue statements identified within the context of the problem situation. These statements must be derived from the problem situation by the users themselves and may reflect such issues as objectives, goals, factors, activities, obstacles, etc.

The relational clause is a single clause that permits the users to make a common comparison of all pair-wise combinations of issue statements in the element set. Thus, in conducting an exercise, the users are subjected to a series of questions in the form "is element A related to element B?" or similar questions more appropriate to the context of the problem situation being addressed.

The digraph is the primary product to be derived from ISMS outputs. It is a directed graph or network model whose nodes represent the original issue statements and whose lines define the relative structure or relationships established by the consensus opinions of the users. After the digraph is examined for completeness and/or possible reinterpretation of relational links, it is used to produce

the interpretative structural model.

The interpretive structural model is the final documentation that records the results of applying the ISM technique to a specific issue context. It is derived from the digraph by introducing appropriate interpretive symbols and/or notation to form a structural model reflecting the user established relationships among the original set of complex issue statements, hence the term interpretive structural modeling.

The relationships of these fundamental concepts are shown diagrammatically in figure 2-2.

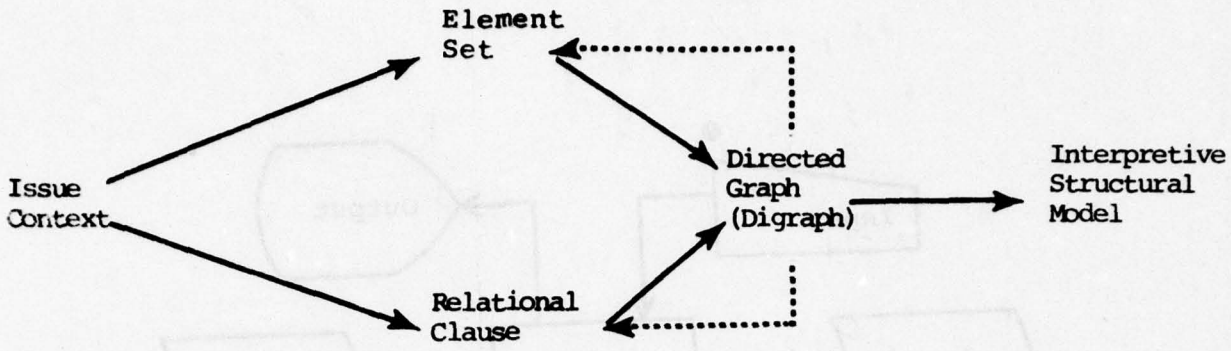

Figure 2-2. The Fundamental Concepts of the Interpretive Structural Modeling Technique. (Arrows denote the presence of activities whereby elements to the left are examined and elaborated in order to determine the elements to the right. Dashed lines indicate feedback and revision.)

2.4 Basic Operational Steps for Application of ISM

In systematically developing the above conceptual elements, it is useful to think of the process as being composed of three operational steps. The first operational step is concerned with extracting a set of relevant issue statements and a meaningful relational clause from a specified issue context. On the basis of a systematic investigation of whether or not the relational clause holds among pairs of issue statements, and using computer aids to perform routine bookkeeping and logical operations, a complete relational pattern is established during the second operational step of an ISM session. This relational pattern is established in the form of a "directed graph" or digraph. In the third operational step, the digraph is examined for completeness and possible reinterpretation of relational links, perhaps even iterating through the computer-aided step with revised issue statements or relational clauses. Appropriate interpretive symbols and/or notation are then introduced to produce an interpretive structural model.

The actual sequence of required operational steps is shown graphically in figure 2-2. This volume is concerned primarily with step 2 of the process. For more information regarding steps 1 and 3, refer to Warfield.(1)

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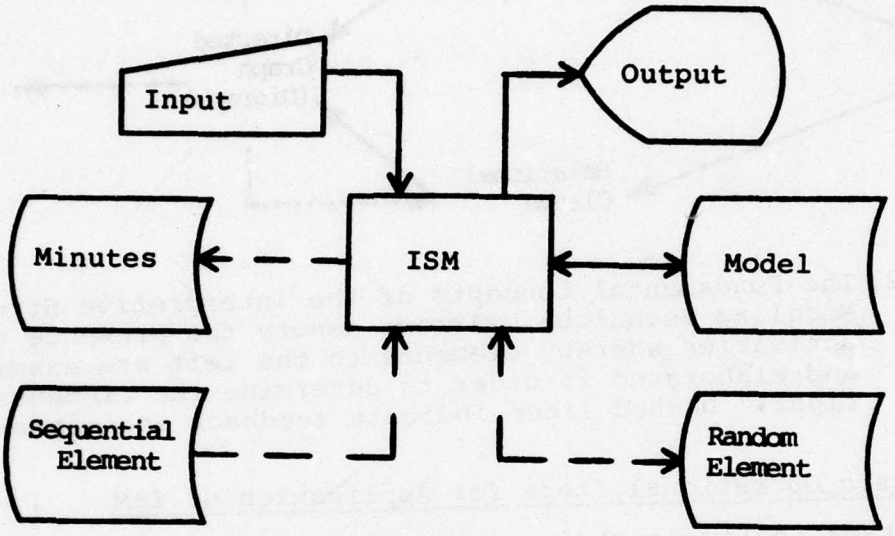
1. Warfield, J. N., Societal Systems, John Wiley and Sons, Inc., 1967.



-----Optional Files

Figure 2-3. File Relationships

2.5 ISM File Relationships

The ISM computer program utilizes four user generated files during a modeling session. They are as follows:

a. Model file

b. Sequential element file (optional)

c. Random element file (optional)

d. Minutes file (optional).

The model file contains the ISM matrix and restart information for sessions which have been interrupted.

The sequential element file contains the text of the relational expression and a listing of the elements to be modeled. Since the information contained in this file is used only for visual comparison by the user, the use of this file is optional.

The random element file is a random access file containing the information of the sequential element file. The ISM program uses a random access file to speed access and execution. The translation from the sequential file to the random file is automatically accomplished by the ISM program. Since the sequential element file may or may not be used, this file is considered optional. However, if the sequential element file is input, the random element file must be generated.

A complete account of all queries, which includes the element set, the relational clause and user responses may be captured on a minutes file. Minutes recorded on this file may be printed on the central site printer, listed on the user's terminal or edited using the H6000 text editor to provide a finished copy ready for duplication. The program will not continue a previous file. If the session is restarted, a new file must be opened.

2.5.1 File Generation. Files to be used by the ISM program may be generated by two methods:

a. The files may be generated before the modeling session using the ACCESS subsystem.(1)

b. Alternatively, the ISM program will generate temporary files when the CAT/FILE string is input by the user. If the information on the program generated

1. Honeywell TSS General Information Manual, DD22, September 1976.

files is needed at a later date (i.e., an interrupted session), the temporary file must be saved.

2.5.2 File Sizing. The size of the user generated file is directly related to the number of elements, the length of the relation expression and the complexity of the model.

The size of the model file is approximately 11 + n/4 little links where n is the number of elements.

The sequential element file and random element file are approximately the same length and can be sized during the creation of the sequential element file.

The minutes file size is difficult to establish since it is dependent on each of the elements listed in the first paragraph of this section. A gross estimate size may be determined by n2/2 little links where n equals the number of elements.

2.6 ISM Output Products

The output products of the ISM System (ISMS) consists of the following: (a) digraph construction aids; and (b) session minutes.

a. Digraph Construction Aids. Following the completion of an ISM question and answer session, digraph construction aids are produced by ISM. These aids include:

(1) Hierarchy level partitioning which lists the achieved hierarchy levels and the elements comprising each level.

(2) Connectives which depict the adjacency connectives between the element set. The elements are relisted in the hierarchy order and each element's connective to higher level elements is noted.

b. Session Minutes. A complete account of all queries, which includes the element set, the relational clause and user responses may be captured on a minutes file. Minutes recorded on this file may be printed on the central site printer, listed on the user's terminal or edited using the H6000 text editor to provide a finished copy ready for duplication. The program will not continue a previous file. If the session is restarted, a new file must be opened.

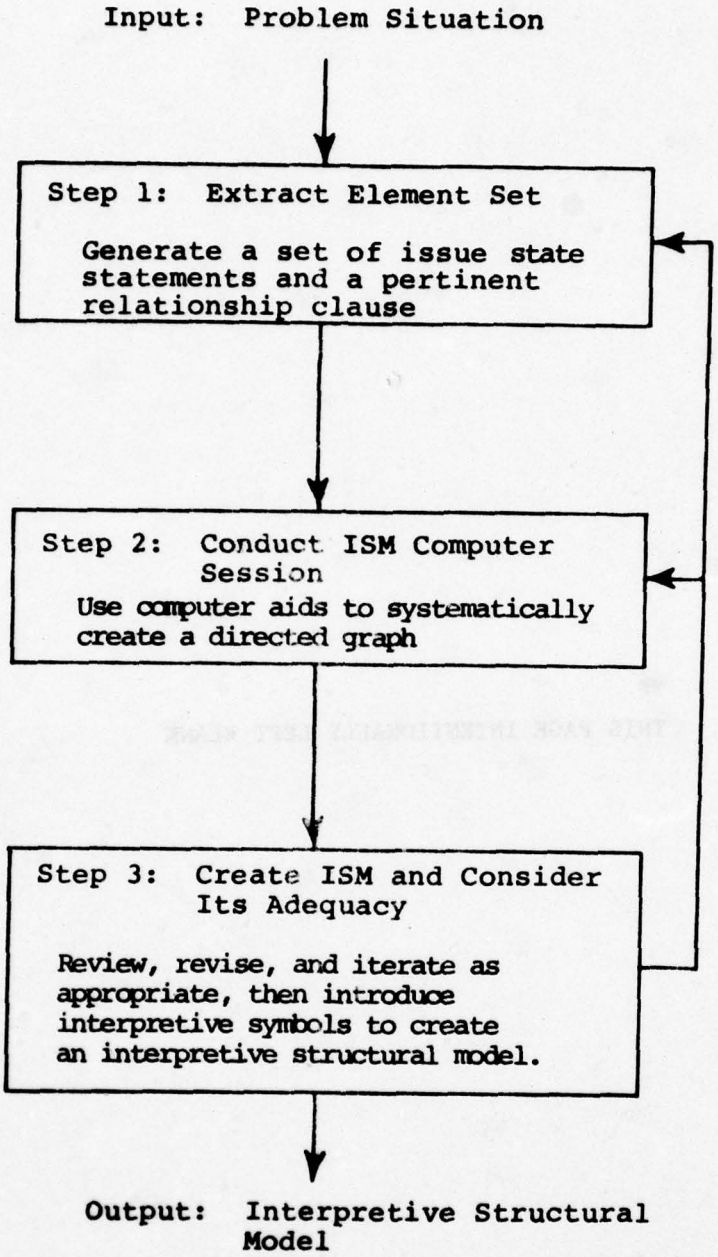


Figure 2-4. The Basic Operational Steps for Application of the ISM Technique.

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3.0 ISM COMMAND DEFINITIONS

This section provides a precise description and definition for each ISM prompt/response and presents these definitons in tabular form as a convenience to the reader. These tabular formats employ certain notation conventions to minimize the narrative and keep the description concise. These conventions are discussed in the next paragraph.

3.1 Notation Convention

The left column of the following tables identifies the dialogue that takes place whenever a command is invoked or a query is responded to. All computer generated text is printed without underscoring. All underscored text is a user response. The lowercase strings represent variable information. User supplied variable information is described in the right column of the tables.

3.2 Text Editor Dialogue

The H6000 text editor is used in the creation and editing of sequential element files. The following tables give a brief review of the procedure for generating a sequential file for processing by the ISM program. For further information on using the H6000 text editor, the user is referred to the time sharing text editor manual.(1)

3.3 ISM Dialogue

Creation of a structural model with computer assistance is accomplished by invoking the ISM program. ISM may utilize an existing text file to display English (or any other language) text queries and accept English or symbolic responses from the user. The user responses are used to determine the relation and interrelationship among elements. ISM directs the relating process until either interruption by the user or completion of the modeling process. Upon completion, ISM displays the hierarchical order of the elements along with the connectives between elements.

3.3.1 User Input to ISM. Whenever ISM requires user response, it prompts with an equal sign (=). The user may then type in the appropriate response. If the user is uncertain as to what is required, the response HELP may be entered. HELP is further described in the next paragraph. Input to ISM is free format and need only contain enough characters to uniquely specify the response. For example, a user wishing help need only type H, although HE, HEL and HELP are all acceptable. HELL is not, however. Free format input permits the user to place his answer anywhere on the

1. Honeywell Time Sharing Text Editor, DD18, August 1976.

terminal line, that is, he may space over a certain number of characters to dress up the hard copy listing. In addition, since ISM stops its scan at the first blank encountered after a response, the remainder of the line may be used to enter descriptive comments about the response.

3.4.2 HELP. ISM provides the user with built-in documentation in the form of the HELP response. Whenever ISM is prompting (=), the user need only type HELP to receive a text explanation of the required input. Many HELP responses are linked so that the user may proceed further with explanation at his option. This linkage is provided via the HLP CMD? prompt, which allows the user to specify further levels of HELP. It is important to remember that ISM prompts with (=) and is expecting a valid response. Some HELP texts return to ISM without giving the user an option to continue.

Table 3-1. Invoking TEXT EDITOR

DIALOGUE	DESCRIPTION
system?	
EDIT NEW	System command which calls the TEXT EDITOR and instructs it to open a new file.
*	Prompt indicates that the TEXT EDITOR is ready to receive a line of text.

Table 3-2. Entering Relational Text

DIALOGUE	DESCRIPTION
	The relational expression is limited to approximately 10 lines of text.
*/RLA	Indicates the next line will be the beginning of the introductory clause.
*text	
*/RLB	Indicates the next line will be the beginning of the relational clause.
*text	
*/RLC	Indicates the next line will be the beginning of the qualifying clause.
*text	

Table 3-3. Entering Element Text

DIALOGUE	DESCRIPTION
*/EL(blank)number	Indicates the beginning of an element text. The key word must be followed by a blank character and the element number.
*text	
*/EL(blank)number	Beginning of the next element.
*text	
*//	Indicates the end of the text input.
*CR	A null line returns to the editor command level.

Table 3-4. Terminating the TEXT EDITOR Session

DIALOGUE	DESCRIPTION
-save cat/file string	System creates a permanent file and saves the text.
-done	Return to system level.

Table 3-5. Invoking ISM Initial Session

DIALOGUE	DESCRIPTION
*run <*argument*>	Command to TSS FORTRAN subsystem to execute ISM. Note: Argument is installation dependent and must be obtained from system maintenance.
CCTC ISM Version 3.0	ISM salutation.
Is this the first run with this model? =Yes	ISM query as to initialize/ restart mode of operation Yes invokes a new session (initialize). The querying will begin with the full element set and a vacant model matrix.
What is the cat/file string of your model?	ISM request for model identification. The user must supply the cat/file string of his model file.
=userid/filename	ISM will access the file and initialize itself.

Table 3-6. Invoking ISM Restart Session

DIALOGUE	DESCRIPTION
*run <*argument*>	Command to TSS FORTRAN subsystem to execute ISM. <*argument*> is installation dependent.
CCTC ISM Version 3.0	
Is this the first run with this model?	
=No	Indicates the user's desire to restart/continue a previously interrupted ISM session.
What is the cat/file string of your model?	
=userid/filename	ISM will access the file and pick up restart information. Filename is the same file as provided during the initial run.

Table 3-7. Interrupting an ISM Session

DIALOGUE	DESCRIPTION
step: n	
We will now relate element 2 to 2 elements.	Typical step notification format varies slightly with program location.
Do you wish to continue?	ISM requests permission to continue.
=r	r=Yes continue the session.
	r=No break/interrupt the session for now and retain the accumulated information on the model file. The session may be restarted by invoking ISM in restart mode.
A file named userid/newfile has been written for restart.	ISM response to an interruption of modeling session.
	Note: You must insure that the model file is permanently saved for future sessions.

Table 3-8. Specifying Full Text Query Mode in Initial Session

DIALOGUE	DESCRIPTION
Are full text queries desired?	
=Yes	Yes response indicates that ISM will enter full text query mode.
What is the cat/file string of the input file?	ISM requests the name of the sequential element file which you have previously created with the text editor (see section 3.2).
=userid/elfile	
What cat/file string do you wish for the saved text?	ISM request for the name of the random element file.
=userid/ranel	
Number of element = n	The ISM program will translate from the sequential file to the random file. The elements will be counted as they are translated.
There were n errors found reading the text.	
Do you wish to stop now? r	The program encountered errors while translating from the sequential file to the random file. The error and the input line causing it (if applicable) are printed. If the errors are of no importance, you may continue with ISM by entering yes. Otherwise, enter no and the program will terminate to allow correction of the input file.

Table 3-9. Specifying New Query Mode in Restart Mode

DIALOGUE	DESCRIPTION
Are full text queries desired?	
=Yes	Yes response indicates that ISM will enter full text query mode.
Do you wish to input new element text?	
=Yes	Yes response informs ISM that unedited sequential element file is to be used. The number of elements in the new file must be the same as the number in the original file. The ISM program will now request the cat/file strings of the sequential and random element files (see table 3-7).

Table 3-10. Specifying Old Query Text in Restart Mode

DIALOGUE	DESCRIPTION
Are full text queries desired?	
=Yes	Yes response indicates that ISM will enter full text query mode.
Do you wish to input new element text?	
=No	No response informs ISM that the existing random element file is to be used.
What is the cat/file string of the saved text?	ISM request for random element file.
=userid/oldran	ISM will access the old file and continue the session at the point it was interrupted.

Table 3-11. Specifying Symbolic Query Mode

DIALOGUE	DESCRIPTION
Are full text queries desired?	
=No	No indicates the user's desire to enter symbolic query mode. This mode does not need a sequential element file and random element file.
How many elements?	
=nn	ISM request the size of the element set. Enter an integer between 2 and 255.

Table 3-12. Specifying Session Minutes

DIALOGUE	DESCRIPTION
Do you wish minutes to be kept?	
=Yes	Yes response instructs ISM to write session minutes on to a file for post session printing.
What cat/file string for minutes?	
=userid/min	ISM request for cat/file string of minutes file.

Table 3-13. Responding to Full Text Queries

DIALOGUE	DESCRIPTION
Responding to queries (full text mode)	
Introductory clause element (a) text relational clause element (b) text qualifying clause	Full text query as defined in text file
=r	r = user response. During PASS1 this may be unidirectional or bidirectional. During PASS2 it must be unidirectional.
	UNIDIRECTIONAL RESPONSES:
	T(true), Y(yes), or SI = (a) is related to (b)
	F(false) or NO = (a) not related to (b)
	PASS1 will reverse the query to determine the relationship of (b) to (a)
	BIDIRECTIONAL RESPONSES
	V, G(gt) or > = (a) related to (b) but (b) not related to (a).
	A, L(lt) or < = (a) not related to (b) (b) related to (a)
	X, EQ, or = = (a) and (b) are identical
	O or NR = (a) and (b) are not related
	Note: In giving allowable responses only the letters in uppercase type need be given. Parentheses enclose the long form.

Table 3-14. Responding to Symbolic Queries

DIALOGUE	DESCRIPTION
Responding to queries (symbolic mode)	
a R b?	Symbolic query where a and b are the numeric indicators for the elements being related
=r	r = user response. User responses are identical to those for full text queries. See Table 3-12 for further details.

Table 3-15. Cycle Display

DIALOGUE	DESCRIPTION
Cycle display	Upon completion of a PASS1 step, any cycles or loops which were detected are displayed as follows:
LOOP ON a = b_1 b_2 ... b_n	a = proxy element number which will represent this group of elements in the remaining steps. b_1 b_2.... b_n = list of elements which were detected as equivalent to element (a).

Table 3-16. Hierarchy Display

DIALOGUE	DESCRIPTION
Hierarchy Display	Upon completion of an ISM session, the elements are displayed in a hierarchical order as follows:
LEVEL 1) = a_1 a_2...a_n	a_1 a_2...a_n
LEVEL 2) = b_1 b_2...b_n	list of elements belonging to the highest order hierarchy level (i.e., they are related to by other elements but do not themselves relate to other elements.)
.	
.	
.	
LEVEL n) = n_1 n_2...n_n	b_1 b_2...b_n = next level
	n_1 n_2...n_n = last level

Table 3-17. Connective Display

DIALOGUE	DESCRIPTION
Connectives display	Following the hierarchy display, ISM displays the connectives between the elements. This display is the guide to creation of an adjacency digraph.
(a) -- a_1 $a_2 \ldots a_n$	(a) = source element
(b) -- b_1 $b_2 \ldots b_n$	a_1 $a_2 \ldots a_n$ = object element list for element (a)
. . .	(b) = source element
(n) -- n_1 $n_2 \ldots n_n$	b_1 $b_2 \ldots b_n$ = object list for (b)
	(n) = last source element
	n_1 $n_2 \ldots n_n$ = object list for (n)

APPENDIX. SELECTED ISM SESSION EXAMPLES

This appendix contains examples of each of the important functions necessary to run the CCTC H6000 implementation of ISM. The examples are arranged as follows:

```
SYSTEM ?EDITOR
OLD OR NEW-NEW
READY
enter
*/RLA
*DOES THE
*/RLB
*REPORT TO THE
*/RLC
*IN THE ACME COMPUTER COMPANY?
*/EL 1
*VICE PRESIDENT OF MARKETING
*/EL 3
*BOARD OF DIRECTORS
*/EL 4
*VICE PRESIDENT OF RESEARCH
*AND DEVELOPMENT
*/EL 2
*SALES MANAGER
*/EL 5
*PERSONNEL DIRECTOR
*/EL 6
*PRESIDENT
*/EL 7
*VICE PRESIDENT FOR OPERATIONS
*SAVE DEL

-SAVE
FILE NAME? C110/ISMTEST/QUEIN3
DATA SAVED-QUEIN3

/RLA

-DONE
SYSTEM ?
```

Figure A-1. Creation of a Sequential Element File

```
CCTC ISM VERSION 3.0

IS THIS THE FIRST RUN WITH THIS MODEL?
=YES
WHAT IS THE CAT/FILE STRING OF YOUR MODEL?
=C110/ISMTEST/MODEL

ARE FULL TEXT QUERIES DESIRED?
=YES
   WHAT IS THE CAT/FILE STRING  OF THE INPUT FILE?
=C110/ISMTEST/QUEIN
   WHAT CAT/FILE STRING DO YOU WISH FOR THE SAVED-TEXT?
=C110/ISMTEST/RANQUE
NUMBER OF ELEMENTS =    7
DO YOU WISH MINUTES TO BE KEPT?
=YES
WHAT FILENAME FOR MINUTES?
=C110/ISMTEST/MIN
```

Figure A-2. Execution of ISM, Initialization.

```
CCTC ISM VERSION 3.0

IS THIS THE FIRST RUN WITH THIS MODEL?
=YES
WHAT IS THE CAT/FILE STRING OF YOUR MODEL?
=C110/ISMTEST/MODEL2
ISM HAS CREATED A TEMPORARY FILE NAMED: MODEL2

ARE FULL TEXT QUERIES DESIRED?
```

Figure A-3. Creation of a Temporary File by ISM.

```
THE FOLLOWING QUERIES MAY BE ANSWERED WITH A
     YES NO GT LT NR EQ


STEP:  1
--------
WE WILL NOW RELATE ELEMENT   1 TO   6 ELEMENTS.
DO YOU WISH TO CONTINUE?
=YES

DOES THE
VICE PRESIDENT OF MARKETING
REPORT TO THE
SALES MANAGER
IN ACME COMPUTER COMPANY?
=GT

DOES THE
VICE PRESIDENT OF MARKETING
REPORT TO THE
BOARD OF DIRECTORS
IN ACME COMPUTER COMPANY?
=LT
.
.
.

DOES THE
VICE PRESIDENT OF MARKETING
REPORT TO THE
VICE PRESIDENT FOR OPERATIONS
IN ACME COMPUTER COMPANY?
=NR

STEP:  2
--------
WE WILL NOW RELATE ELEMENT   3 TO   1 ELEMENTS.
DO YOU WISH TO CONTINUE?
=YES

DOES THE
BOARD OF DIRECTORS
REPORT TO THE
PRESIDENT
IN ACME COMPUTER COMPANY?
=GT

STEP:  3
--------
WE WILL NOW RELATE ELEMENT   4 TO   2 ELEMENTS.
DO YOU WISH TO CONTINUE?
=YES
```

Figure A-4. ISM Pass 1 Dialogue.

```
CCTC ISM VERSION 3.0

IS THIS THE FIRST RUN WITH THIS MODEL?
=HELP
   ISM has the capability of restarting sessions. A YES
answer causes initialization of the tables and beginning
a new problem.  A NO answer tells ISM that you are
continuing with a previously initialized problem.

TYPE

C - To continue
G - General description of ISM
S - General rules for input to ISM
HELP COMMAND?
=C
          :
=YES
WHAT IS THE CAT/FILE STRING OF YOUR MODEL?
=HELP
    ISM keeps key information about a problem on a file
called the model file.  Respond to this question with a
CAT/FILE string.  For an initialization run, give any
CAT/FILE that you wish.  For a restart, give the
CAT/FILE of the model file you saved from the previous
session.

TYPE:

C - To continue
D - Description of CAT/FILE strings
S - ISM input rules
HELP COMMAND?
```

Figure A-5. ISM HELP Example.

```
DOES THE
VICE PRESIDENT OF MARKETING
REPORT TO THE
BOARD OF DIRECTORS
IN THE ACME COMPUTER COMPANY?

=WRONG
(35) COMMAND NOT RECOGNIZED.
PLEASE REENTER.
:
```

Figure A-6. ISM ERROR Message Example.

```
DOES THE
VICE PRESIDENT OF RESEARCH AND
DEVELOPMENT
REPORT TO THE
VICE PRESIDENT FOR OPERATIONS
IN ACME COMPUTER COMPANY?
=NR

STEP:  4
--------
WE WILL NOW RELATE ELEMENT   5 TO   1 ELEMENTS.
DO YOU WISH TO CONTINUE?
=NO

A FILE NAMED C110/ISMTEWRITTEN FOR RESTART
YOU MAY EXAMINE MINUTES BY PRINTING FILE C110/ISMTE
```

Figure A-7. Interruption of ISM Session.

```
CCTC ISM VERSION 3.0

IS THIS THE FIRST RUN WITH THIS MODEL?
=NO
WHAT IS THE CAT/FILE STRING OF YOUR MODEL?
=C110/ISMTEST/MODEL

ARE FULL TEXT QUERIES DESIRED?
=YES
   DO YOU WISH TO INPUT NEW ELEMENT TEXT?
=NO
   WHAT IS THE CAT/FILE STRING OF THE SAVED-TEXT ?
=C110/ISMTEST/RANQUE
DO YOU WISH MINUTES TO BE KEPT?
=YES
WHAT FILENAME FOR MINUTES?
=C110/ISMTEST/MIN2
ISM HAS CREATED A TEMPORARY FILE NAMED: MIN2

STEP:  4
--------
WE WILL NOW RELATE ELEMENT    5 TO    1 ELEMENTS.
DO YOU WISH TO CONTINUE?
=YES
```

Figure A-8. Execution of ISM, Restart.

```
  ANSWER THE FOLLOWING QUESTIONS WITH
          TRUE FALSE YES OR NO

          STEP  5
          =======
WE WILL NOW INTERRELATE  3 ELEMENTS WITH  2 ELEMENTS.
DO YOU WISH TO CONTINUE?
=YES

DOES THE
PERSONNEL DIRECTOR
REPORT TO THE
BOARD OF DIRECTORS
IN ACME COMPUTER COMPANY?
=YES

DOES THE
VICE PRESIDENT FOR OPERATIONS
REPORT TO THE
PRESIDENT
IN ACME COMPUTER COMPANY?
=YES

DOES THE
PERSONNEL DIRECTOR
REPORT TO THE
PRESIDENT
IN ACME COMPUTER COMPANY?
=YES
```

Figure A-9. ISM Pass 2 Dialogue.

```
                STEP 7
                ******

LEVEL    1)=    3

LEVEL    2)=    6

LEVEL    3)=    1    4    5

LEVEL    4)=    7    2

                STEP 8
                ******

(  6) ==>    3

(  1) ==>    6

(  4) ==>    6

(  5) ==>    6

(  7) ==>    5

(  2) ==>    1
```

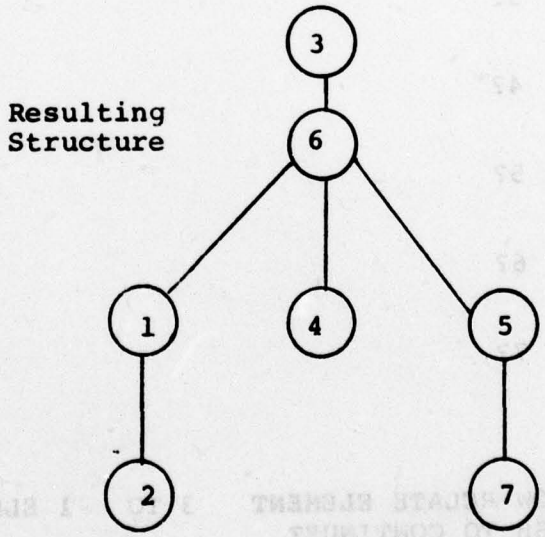

Figure A-10. Digraph Construction Aid Printout

```
CCTC ISM VERSION 3.0

IS THIS THE FIRST RUN WITH THIS MODEL?
=YES
WHAT IS THE CAT/FILE STRING OF YOUR MODEL?
=C110/ISMTEST/MODEL

ARE FULL TEXT QUERIES DESIRED?
=NO
DO YOU WISH MINUTES TO BE KEPT?
=NO
HOW MANY ELEMENTS?
=7

THE FOLLOWING QUERIES MAY BE ANSWERED WITH A
     YES NO GT LT NR EQ


STEP:  1
--------
WE WILL NOW RELATE ELEMENT   1 TO   6 ELEMENTS.
DO YOU WISH TO CONTINUE?
=YES

   1 R    2?
=GT

   1 R    3?
=LT

   1 R    4?
=NR

   1 R    5?
=NR

   1 R    6?
=LT

   1 R    7?
=NR

STEP:  2
--------
WE WILL NOW RELATE ELEMENT   3 TO   1 ELEMENTS.
DO YOU WISH TO CONTINUE?
=YES

   3 R    6?
=GT
```

Figure A-11. Execution of ISM in Symbolic Query Mode.

```
OLD C110/ISMTEST/MIN
READY
*LIST

 DOES THE
 VICE PRESIDENT OF MARKETING
 REPORT TO THE
 SALES MANAGER
 IN ACME COMPUTER COMPANY?
   ::GT
 DOES THE
 VICE PRESIDENT OF MARKETING
 REPORT TO THE
 BOARD OF DIRECTORS
 IN ACME COMPUTER COMPANY?
   ::LT
 DOES THE
 VICE PRESIDENT OF MARKETING
 REPORT TO THE
 VICE PRESIDENT OF RESEARCH AND
 DEVELOPMENT
 IN ACME COMPUTER COMPANY?
   ::NR
 DOES THE
 VICE PRESIDENT OF MARKETING
 REPORT TO THE
 PERSONNEL DIRECTOR
 IN ACME COMPUTER COMPANY?
   ::NR
 DOES THE
 VICE PRESIDENT OF MARKETING
 REPORT TO THE
 PRESIDENT
 IN ACME COMPUTER COMPANY?
   ::LT
 DOES THE
 VICE PRESIDENT OF MARKETING
 REPORT TO THE
 VICE PRESIDENT FOR OPERATIONS
 IN ACME COMPUTER COMPANY?
   ::NR
 DOES THE
 BOARD OF DIRECTORS
 REPORT TO THE
 PRESIDENT
 IN ACME COMPUTER COMPANY?
   ::GT
```

Figure A-12. Listing of ISM Minutes File.

```
*DONE
SYSTEM ?BYE

   1 TEMPORARY FILES CREATED.

MODEL2  ? SAVE
FILE NAME? C110/ISMTEST/MODEL2
**cost:  $    6.50 to date:  $    25.05=  0%
**on at  8.945 - off at  9.531 on  06/27/78


CP DISCONNECTS
```

Figure A-13. Saving Temporary Files at Sign-Off.

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The interpretive structural modeling process transforms unclear, poorly articulated mental models of systems into visible, well-defined models useful for many purposes. This is done through the systematic interative application of graph theory to produce a directed graph of a particular contextual relationship among an element set. This manual briefly describes interpretive structural

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Item 20, Continued.
modeling, then documents an interactive computer program developed to assist in the modeling process. The program is written in FORTRAN and operates on a Honeywell H6000 Under GCOS TSS.